International Journal of Bio-resource and Stress Management

https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM November 2024, 15(11): 01-13

Article AR5728

Research Article

Stress Management

DOI: HTTPS://DOI.ORG/10.23910/1.2024.5728

Pollution Sensitivity and Resistance Assessment of Native Ornamental Plants for Landscaping in Various Factories

Pavan Kumar Avilala[1], M. Raja Naik[1], D. Sreedhar[2], V. V. Padmaja[3] and P. Chakradhar[4]

[1]Dept. of Floriculture and Landscaping, [3]Dept. of Plant Physiology, College of Horticulture, Dr. YSRHU, Anantharajupeta, Andhra Pradesh (516 105), India

[2]Dept. of Horticulture, Horticultural Research Station, Anantharajupeta, Andhra Pradesh (516 105), India

[4]Dept. of Landscaping and Nursery, Sri City Pvt. Ltd., Andhra Pradesh (517 646), India

Open Access

Corresponding pavankumaravilala@gmail.com

0009-0003-0850-668X

ABSTRACT

The present study was conducted during 2023–2024 and the data was recorded during *post monsoon* period (January– February, 2024) to assess the performance of ten native ornamental plants under different pollutants of seven factory sites along with a control in Rayalaseema region of Andhra Pradesh, India, for recommending in green belt development under multiple polluted sites. The data recorded for various parameters under study showed that among the plants tested, *Cordyline terminalis* at Control site i.e. College of Horticulture reported maximum values for canopy spread (59.54 cm^2), leaf extract pH (7.49) and total chlorophyll content (3.86 mg g^{-1}), while it recorded maximum values for ascorbic acid content (13.00 mg g^{-1}), relative water content (89.54%), proline content (9.19 µmoles g^{-1}) and superoxide dismutase activity (4.23 O.D. min^{-1} g^{-1}) at APMDC factory site. *Barleria cristata* recorded superior values for Stomatal Index (33.40%) at College of Horticulture (control site) and Chlorophyll stability index (98.04%) at polluted site of APMDC. Phenol content was reported highest in *Ixora coccinea* (18.96 mg 100 g^{-1}) at mining site (APMDC). *Nyctanthus arbor-tristis* at APMDC site had reported maximum value for Dust capturing capacity (0.31 mg cm^{-2}). The Data on specific leaf weight showed non significance difference. *Cordyline terminalis* with superior biochemical traits showed higher Air Pollution Tolerance Index (APTI) values (21.86) at APMDC mining site while, *Nyctanthus arbor-tristis* with an Anticipated Performance Index (API) grade of 5 has been assessed as a very good performer under polluted sites.

KEYWORDS: APTI, API, native ornamental plants, multiple polluted sites

***Citation* (VANCOUVER):** Avilala et al., Pollution Sensitivity and Resistance Assessment of Native Ornamental Plants for Landscaping in Various Factories. *International Journal of Bio-resource and Stress Management,* 2024; 15(11), 01-13. HTTPS://DOI.ORG/10.23910/1.2024.5728.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 21st August 2024 RECEIVED in revised form on 27th October 2024 ACCEPTED in final form on 15th November 2024 PUBLISHED on 23rd November 2024

1. INTRODUCTION

Pollution is a serious environmental problem arises when harmful materials are introduced into the environment, it can have a negative impact on ecosystems, wildlife, plants, and human health (Olumi et al., 2016). Urban air pollution is rising in developing countries due to rapid urbanization and industrialization, leading to significant contamination of air, water, and soil by pollutants (Bang, 2012). The overall well-being of the people is determined by air quality (Uka et al., 2017). According to biennial report by Yale and Columbia Universities, the World Economic Forum, and the State of India's Environment (SoE) 2018, India ranks third among the five least polluted countries in the world on the Environmental Performance Index (EPI) 2018, down 36 spots from 141 in 2016. The country's overall low ranking of 177 out of 180 is linked to poor performance in the environmental health issue (Gupta et al., 2020). Seven million premature deaths are expected to occur each year due to air pollution, which is the biggest environmental danger to public health globally. One in nine deaths globally is attributed to air pollution, which is a serious global health concern.

As a result of population growth, industrialization, and urbanization, air pollution is of concern and is likely to get worse over the coming years (Banerjee et al., 2011). The alternate approach in pollution mitigating through economically feasible, eco-friendly and sustainable means is by use of green plants (Nugrahani et al., 2012). Plants are fundamental to our ecosystem, with trees and shrubs, as perennial components of the landscape, playing a pivotal role in ameliorating environmental conditions (Ahmad et al., 2019). Through actively getting involved in the cycling of nutrients and gases like carbon dioxide and oxygen, they play a crucial role in monitoring and preserving the ecological balance. They also provide a large amount of leaf area for the impingement, absorption, and accumulation of air pollutants, which lowers the level of pollution in the environment (Escobedo et al., 2008). Research indicates that vegetation can decrease airborne particulate matter by approximately one-third compared to regions devoid of plant life (Setala et al., 2013).

The ornamentals plants either trees, shrubs, climbers, ground covers or grasses which are used in landscaping become an important and integral part of that area. Selection of suitable ornamental plants and their scientific management of ornamental plants has also opened the doors to minimize the deleterious effects of air pollutions in those areas (Kapoor, 2017). Ornamental plants besides beautification can be used in treating polluted areas and as a source of income with high added value. Ornamental plants have high stress tolerance, rapid growth, high biomass production, and good root development. As these are not consumed by animal and human, the problem of contaminants entering food chain can be avoided in addition to improving the environments with aesthetic value (Rocha et al., 2022). The selection of suitable plant species and their use in biomonitoring practices are crucial for formulating sustainable landscape designs in industrial and urban environments. (Ahmad et al., 2019). The Air Pollution Tolerance Index (APTI) is an effective tool for evaluating various plants to assess their susceptibility or tolerance to different pollutants (Hassanen et al., 2016). Anticipated performance index (API) along with APTI and other socio-economic traits (Govindaraju et al., 2012) can be used in screening the plants for green belt development in industrial areas that clean up the environment (Ogunkunle et al., 2015). So, the present work has been taken up to select the suitable tolerant native ornamental plants that has better adaptability and for potent pollution mitigation and in landscaping and green belt development under factory areas.

2. MATERIALS AND METHODS

2.1. Study sites

The present study was carried out during *post monsoon season* (January–February, 2024) at seven factory sites with varied atmosphere and pollutants *viz*., a Control site, College of Horticulture Anantharajupeta (L_1), Andhra Pradesh Mining Development Corporation (APMDC), Mangampeta, Rly Kodur, Andhra Pradesh.(L_2), Andhra Pradesh State Road Transport Corporation (APSRTC) garages, Tirupati. (L_3), Carriage repair shop (South Central Railway), Renigunta (L_4), Electro steel casting limited, Sri Kalahasthi (L_5), Vinayaka cements, Yerpedu (L_6), Rachana plastics, Gajulamandyam (L_7) and SIBAR Autoparts Ltd. Tukivakam (L_8).

2.2. Plant material

Ten native ornamental plants (Table 1) were selected for present study. Plants of similar age, uniform and healthy state were selected and placed in the study sites and maintained properly with timely nutrients, water and plant protection measures in all study areas with regular supervision.

The leaf samples were carefully cut off from the plants with scissors and were kept in airtight polyethylene bags and brought to the laboratory for further analysis. All the leaf samples were stored at −20°C until further biochemical analysis. The data on Canopy spread, Stomatal index (Salisbury, 1927), Specific leaf weight (Kuo et al., 1980), Ascorbic acid (Ranganna, 1977), Leaf extract pH (Prasad and Rao, 1982), Total chlorophyll content (Barnes et al., 1992), Relative water content (Singh, 1977), Chlorophyll stability index (Murthy and Majumdar, 1962), Total phenols (Singleton et al., 1965), Proline content (Bates et al., 1973),

Table 1: General description of ornamental plants used for the study

Notation	Common name	Botanical name	Family	Plant type
OP_1	Philippine Violet	*Barleria cristata*	Acanthaceae	Shrub
OP_2	Spider plant	*Chlorophytum como-sum*	Asparagaceae	Perennial evergreen herb
OP_3	Ti plant	*Cordyline terminalis*	Asparagaceae	Shrub
OP_4	Rainbow tree	*Dracaena angustifolia*	Asparagaceae	Shrub
OP_5	Song of India	*Dracaena reflexa*	Asparagaceae	Shrub
OP_6	Jungle Geranium	*Ixora coccinea*	Rubiaceae	Shrub
OP_7	Ming Arelia	*Polyscias fruiticosa*	Annonaceae	Shrub to small tree
OP_8	Coral jasmine	*Nyctanthus arbortristis*	Oleaceae	Shrub to small tree
OP_9	Snake plant	*Sansevieria roxburghiana*	Asparagaceae	Stem less fleshy herb
OP_{10}	Pinwheel flower	*Tabernaemontana divaricata*	Apocynaceae	Shrub

Superoxide dismutase activity (Sadasivam and Manickam, 1996), Dust capturing capacity (Manisha and Pal, 2014), Air Pollution Tolerance Index (APTI) (Govindaraju et al., 2012) and Anticipated Performance Index (API) (Govindaraju et al., 2012) was recorded with the mentioned standard procedures.

Variation in different physiological, biochemical parameters, pattern and their significance level were computed using Analysis of Variance Technique (Two-factor analysis) with different locations and ornamental plants as two factors for analysis. The significance of the analysed data was tabled at 5% level of significance using OPSTAT software.

3. RESULTS AND DISCUSSION

3.1. *Canopy spread*

Canopy spread (Table 2) showed a significant difference within the plants, locations and in interactions. Among native ornamental plants, canopy spread recorded was maximum in *Cordyline terminalis* (55.07 cm^2), among the study locations, College of Horticulture (Control site) had maximum spread (38.40 cm^2). While, in interactions *Cordyline terminalis*×College of Horticulture (Control site) exhibited highest value (59.54 cm^2). This could be attributed to genetic make of the plants. The difference in canopy spread was observed between polluted and control sites where the increase in canopy spread was less in polluted areas when compared with plants at control site. This difference might be due to different pollutants in the environment.

3.2. *Stomatal index*

The data corresponding to stomatal index (Table 2) studied in various ornamental plants revealed that significantly higher stomatal Index was observed in *Barleria cristata*

Table 2: Response of native ornamental plants (OP), locations (L) and their interaction (OP×L) to various pollutants in respect of biometric traits

Orn. Plants	Canopy Spread (cm^2)								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	27.8	21.8	22.5	24.3	25.2	23.1	23.1	20.6	23.6
OP_2	54.9	49.5	43.4	40.5	47.6	45.3	42.4	44.3	46.0
OP_3	59.5	58.4	53.3	53.3	59.1	51.3	54.4	50.9	55.0
OP_4	56.7	53.9	56.1	51.5	51.6	46.9	47.2	51.4	51.9
OP_5	28.0	27.1	26.4	27.5	23.5	27.4	27.2	26.3	26.7
OP_6	27.4	21.8	26.5	26.2	25.9	26.6	23.3	23.8	25.2
OP_7	15.7	15.6	18.6	14.1	17.5	12.6	24.4	20.0	17.3
OP_8	24.3	23.5	21.5	18.4	20.7	21.7	22.7	18.0	21.4
OP_9	31.6	36.3	28.2	27.4	31.8	29.7	28.1	28.1	30.2
OP_{10}	56.5	53.1	53.0	54.6	52.7	53.6	52.6	49.9	53.3
Mean	38.4	36.2	35.1	34.0	35.6	34.0	34.6	33.4	
CD (p<0.05)		L 0.85		OP 0.95		L×OP 2.71			

Table 2: Continue...

Orn. Plants	Stomatal index (%)								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	33.4	27.24	30.26	29.27	26.21	28.77	30.14	29.63	29.36
OP_2	23.24	16.22	17.28	16.92	15.49	19.26	20.21	21.75	18.79
OP_3	28.96	24.69	26.31	25.98	24.77	26.88	27.83	25.39	26.35
OP_4	22.78	18.76	20.36	19.28	18.74	20.69	21.74	20.96	20.41
OP_5	22.38	19.74	20.76	18.34	19.22	19.31	20.49	19.77	20.00
OP_6	26.97	24.31	25.29	24.39	23.87	23.97	26.17	25.31	25.03
OP_7	23.94	19.19	20.97	18.72	19.08	21.18	20.28	19.76	20.39
OP_8	21.98	20.72	21.28	19.76	20.27	19.73	21.17	20.88	20.72
OP_9	18.21	13.69	17.24	16.22	12.19	11.29	15.49	13.91	14.78
OP_{10}	29.8	24.38	28.73	26.31	23.61	24.28	28.34	26.72	26.52
Mean	25.166	20.894	22.848	21.519	20.345	21.536	23.186	22.408	
CD (p<0.05)		L 0.164		OP 0.184		L×OP 0.520			

(29.31%). College of Horticulture (control) had maximum stomatal index (25.16%) among locations and in interactions it was observed highest (33.40%) in *Barleria cristata*×College of Horticulture. Stomatal index recorded was maximum at control site whereas, it was reduced significantly at polluted sites. Reduction in stomatal index at polluted sites might be attributed to the heavily polluted air, containing mainly suspended particulate matter (PM) in conjunction with gaseous pollutants (Rai, 2016).

3.3. Ascorbic acid

Ascorbic acid (Table 3) a stress reducing factor was registered significantly higher in *Cordyline terminalis* (10.33 mg g^{-1}) among the plants. And in locations, it was obtained highest at APMDC (7.20 mg g^{-1}), while the combination of *Cordyline terminalis*×APMDC attained maximum value (13.00 mg g^{-1}). Ascorbic acid is present in pollution tolerant plant species generally in higher levels (Rai and Panda, 2015). Ascorbic acid content was found to be higher at the polluted sites which is believed to induce tolerance to the plants with higher content. Ascorbic acid is not only an antioxidant that protects plants from environmental threats like air pollution, but it is also a powerful reducing agent that activates many defence and physiological mechanisms in the plant (Keller and Schwager, 1977; Lima et al., 2000). Our findings got support from the above authors revealed results.

Table 3: Response of native ornamental plants (OP), locations (L) and their interaction (OP×L) to various pollutants in respect of biochemical traits

Orn. Plants	Ascorbic acid (mg g^{-1})								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	5.78	9.55	7.23	6.03	9.63	9.63	9.01	10.59	8.43
OP_2	1.25	3.24	2.52	1.89	4.95	2.34	2.07	2.17	2.55
OP_3	6.12	13.00	7.98	11.39	10.80	12.77	10.71	9.90	10.33
OP_4	2.26	6.24	3.71	3.69	4.50	4.51	4.14	3.96	4.12
OP_5	1.53	5.02	3.69	4.95	5.67	3.91	5.04	5.31	4.39
OP_6	4.86	10.44	6.33	5.94	9.36	9.77	9.36	4.77	7.60
OP_7	1.62	3.78	3.6	2.79	2.79	2.61	3.41	3.06	2.95
OP_8	2.16	5.56	5.13	5.85	6.48	4.50	5.39	5.22	5.03
OP_9	4.59	6.41	6.32	8.19	5.31	8.01	4.77	6.84	6.30
OP_{10}	5.24	8.76	5.76	5.85	7.37	8.74	7.50	8.82	7.25
Mean	3.54	7.20	5.22	5.65	6.68	6.68	6.14	6.06	
CD (p<0.05)		L 0.063		OP 0.071		L×OP 0.200			

Table 3: Continue...

Orn. Plants	Leaf extract pH								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	6.99	7.00	7.00	7.15	6.96	7.07	6.81	6.97	6.99
OP_2	7.19	6.65	6.58	6.76	6.62	6.78	6.50	6.72	6.72
OP_3	7.49	7.00	7.34	7.06	7.04	6.84	7.08	6.91	7.09
OP_4	7.21	6.78	6.52	6.99	6.07	6.87	6.39	6.78	6.70
OP_5	7.08	6.93	6.34	6.77	6.36	7.07	6.47	6.88	6.74
OP_6	7.35	6.97	7.24	6.80	6.55	6.96	6.93	6.68	6.93
OP_7	7.06	7.07	7.07	6.82	6.50	6.83	6.84	7.01	6.90
OP_8	7.11	6.81	7.20	6.93	7.05	6.75	6.60	7.06	6.94
OP_9	7.04	6.88	7.10	6.87	6.92	6.90	6.69	6.94	6.92
OP_{10}	7.09	6.92	7.27	6.96	6.30	7.16	6.67	6.82	6.90
Mean	7.16	6.90	6.96	6.91	6.64	6.92	6.70	6.87	
CD (p<0.05)		L 0.016		OP 0.017		L×OP 0.049			

3.4. *Leaf extract pH*

The leaf extract pH (Table 3) showed significant difference among ornamental plants, locations and in interactions. *Cordyline terminalis* among plants reported maximum leaf extract pH (7.09), in the locations, College of Horticulture (Control site) registered maximum pH (7.16) and in interactions, *Cordyline terminalis*×College of Horticulture showed highest value (7.49). This might be due to the plants with comparatively higher leaf pH provide better resistance against pollutants by converting sugars into ascorbic acid and enhancing the reducing power of ascorbic acid (Pravin and Madhumita, 2013). Leaf extract pH is important for many of the cellular functions in plants. The data furnished showed that leaf extract pH was enhanced in control site and decreased in other locations could be due to the presence of acidic pollutants in the industrial zone or in response to different metabolic changes due to the presence of specific pollutants (Ahmad et al., 2019). The pH is an indication of the development of detoxification mechanism in plant species necessary for pollution tolerance (Suganthi et al., 2013).

3.5. *Relative water content*

The data pertaining to Relative water content (RWC) (Table 4) studied in various ornamental plants at multiple polluted sites had significant influence and was displayed maximum (86.15%) in *Cordyline terminalis,* among the

Table 4: Response of native ornamental plants (OP), locations (L) and their interaction (OP×L) to various pollutants in respect of biochemical traits

Orn. plants	Relative water content (%)								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	77.35	83.38	86.26	86.67	78.88	83.39	82.60	81.75	82.53
OP_2	73.50	79.28	76.60	73.86	75.83	80.30	78.02	71.02	76.05
OP_3	79.95	89.54	89.08	83.14	88.35	85.34	86.41	87.38	86.15
OP_4	77.89	81.85	80.76	82.02	80.56	76.05	78.42	76.38	79.24
OP_5	75.22	81.35	80.87	81.78	78.26	73.09	76.84	75.68	77.89
OP_6	72.47	78.93	78.88	82.93	82.74	77.55	81.00	84.08	79.82
OP_7	74.51	80.89	77.06	79.28	80.64	82.09	77.26	77.93	78.71
OP_8	71.29	79.22	79.81	80.50	84.42	81.78	83.87	78.83	79.96
OP_9	82.19	86.95	83.06	84.53	80.13	82.72	82.98	84.90	83.43
OP_{10}	74.31	83.95	85.40	81.79	82.14	85.78	80.41	83.26	82.13
Mean	75.87	82.53	81.78	81.65	81.19	80.81	80.78	80.12	
CD (p<0.05)		L 0.788		OP 0.881		L×OP 2.493			

Orn. plants	Total chlorophyll content (mg g^{-1})								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	3.62	2.63	3.38	2.70	3.04	2.16	2.48	2.58	2.82
OP_2	1.18	0.42	0.66	0.54	0.27	0.69	0.42	0.70	0.61
OP_3	3.86	2.92	3.58	2.85	3.28	2.41	2.68	2.39	2.99
OP_4	0.59	0.34	1.08	0.36	0.31	0.77	0.36	0.38	0.52
OP_5	0.83	0.69	0.91	0.44	0.87	0.71	0.44	0.38	0.66
OP_6	2.64	2.03	2.28	1.98	2.46	2.18	1.89	2.19	2.20
OP_7	1.56	1.21	1.02	1.14	0.92	0.96	1.00	1.75	1.19
OP_8	2.29	1.93	1.71	2.08	1.82	1.88	1.69	2.06	1.93
OP_9	1.94	1.74	1.64	1.52	1.92	0.84	0.87	1.46	1.49
OP_{10}	3.57	2.43	2.86	1.98	2.18	2.24	2.08	1.95	2.41
Mean	2.21	1.63	1.91	1.56	1.71	1.48	1.39	1.58	
CD (p<0.05)		L 0.014		OP 0.016		L×OP 0.045			

locations APMDC had maximum RWC (82.53%). In the interactions, *Cordyline terminalis*×APMDC attained highest reading (89.54%). The possible reason for the revealed findings might be due to the higher values of RWC show better tolerant to stress and well-conducting of different physiological mechanisms. When plants are confronted with non-biological stress such as air pollution, their water content increases, and physiological equilibrium is maintained, to resist the stress. This was in conformity with the findings of Verma and Dubey, 2003; Rai et al., 2013.

3.6. Total chlorophyll content

From the data recorded in the table 4, it was observed that *Cordyline terminalis* among ornamental plants (2.99 mg g^{-1}), College of Horticulture (Control site) (2.21 mg g^{-1}) among the locations and *Cordyline terminalis*×*College of Horticulture* (*3.86* mg g^{-1}) in combinations recorded highest total chlorophyll content. The plants with higher total chlorophyll content are considered pollution tolerant (Kuddus et al., 2011). The reason for the above findings clarifies that total chlorophyll content became lower in areas with high pollution because leaf surfaces were covered with pollutants which ultimately leads to blockage of stomata pores and a decrease in photosynthetic productivity (Rai and Panda, 2015) and several pollutants like sulphur dioxide a common pollutant reduces the leaf chlorophyll content. The differences in total chlorophyll content between plant species might also be due to the genetic variations (Bharadwaj et al., 2021)

3.7. Chlorophyll stability index

The recorded data (Table 5) on chlorophyll stability Index (CSI) showed significant difference in two factors and was maximum in *Barleria cristata* (84.54%) among the ornamental plants. In the sites highest value was registered in APMDC (84.34%) and in interactions, *Barleria cristata*×APMDC showed maximum CSI (98.04%). A higher CSI value shows minimum effect on chlorophyll due to the stress. Plants with higher CSI values helps to withstand stress through better availability of chlorophyll which leads to increased photosynthetic rate, more dry matter production and higher productivity (Mohan et al., 2000).

3.8. Total phenol content

Data from table 5 disclosed that among plants, *Ixora coccinea* (12.07 mg 100 g^{-1}), among locations, APMDC (6.17 mg 100 g^{-1}) and in interactions, *Ixora coccinea* at APMDC (18.96 mg 100 g^{-1}) recorded significantly highest phenol content. Phenolic metabolites are accumulated in plant tissues due to biological and non-biological stresses. They are involved in the scavenging of reactive oxygen species through antioxidant enzymes or by directly chelating metals and also inhibits proliferation and progression of the oxidation chain through reducing lipid auto-oxidation or decomposing peroxides (Kovacik and Backor, 2007). Increase of phenol content at polluted region might be due to the stress caused by air pollutants (Mukherjee et al., 2019) and this might be consider as a resistance mechanism adopted by plants to protect (Azzazy, 2020; Hazarika et al., 2023)

3.9. Proline content

Significant difference was observed on the above trait (Table 6). *Cordyline terminalis* among the ornamental plants displayed higher proline content (6.40 µmoles g^{-1}). Among the study locations, APMDC recorded maximum value (6.17 µmoles g^{-1}) and in interaction, higher proline concentration was detected in the combination *Cordyline terminalis*×APMDC (9.19 µmoles g^{-1}). The present study showed an increase in proline content among the plants

Table 5: Response of native ornamental plants (OP), locations (L) and their interaction (OP×L) to various pollutants in respect of biochemical traits

Orn. plants	Chlorophyll stability index (%)								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	87.69	98.04	97.16	96.75	69.82	54.85	88.65	83.33	84.54
OP_2	41.14	63.89	51.26	60.21	37.58	65.24	53.01	50.11	52.80
OP_3	52.26	92.69	73.59	88.95	76.38	83.95	82.84	94.41	80.63
OP_4	44.79	85.27	78.35	84.39	53.01	90.60	61.65	81.19	72.40
OP_5	69.31	93.67	63.79	87.28	50.31	70.23	97.15	40.00	71.47
OP_6	51.33	75.88	58.72	82.97	85.69	80.44	73.25	84.70	74.12
OP_7	60.17	86.53	56.79	49.37	63.21	70.85	75.49	74.40	67.10
OP_8	44.27	71.89	59.34	55.53	78.60	74.51	71.52	95.66	68.92
OP_9	32.10	90.06	46.72	85.58	58.66	70.63	88.81	48.30	65.11
OP_{10}	79.65	85.52	84.51	74.38	60.34	77.31	73.73	86.28	77.71
Mean	56.27	84.34	67.02	76.54	63.36	73.86	76.61	73.84	
CD (p<0.05)		L 0.810		OP 0.906		L×OP 2.562			

Table 5: Continue...

Orn. plants	Total phenol content (mg 100 g^{-1})								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	3.01	4.00	3.74	2.11	2.30	3.45	4.75	4.12	3.43
OP_2	0.47	0.69	0.58	9.72	3.39	2.84	3.18	1.73	2.82
OP_3	4.22	2.28	4.61	14.40	11.28	9.59	4.20	5.36	6.99
OP_4	4.58	5.90	1.21	6.53	1.20	2.01	1.84	2.20	3.18
OP_5	1.89	6.31	2.25	5.17	4.16	4.41	2.60	2.25	3.63
OP_6	4.17	18.96	8.02	6.32	13.65	18.96	9.33	17.19	12.07
OP_7	1.69	4.92	1.57	1.75	5.35	5.34	3.53	4.90	3.63
OP_8	3.51	10.62	3.24	2.03	8.52	5.20	3.61	3.48	5.03
OP_9	1.02	3.35	1.00	2.47	2.09	2.98	0.55	1.17	1.83
OP_{10}	4.01	4.65	4.00	2.09	6.71	4.85	2.81	6.36	4.43
Mean	2.86	6.17	3.02	5.26	5.87	5.96	3.64	4.88	
CD (p<0.05)		L 0.064		OP 0.072		L×OP 0.202			

at factory sites when compared with the control site. The higher proline content act as an inhibitor for air pollution-induced lipid peroxidation (Gupta et al., 2015). It regulates osmosis, protects photosynthetic components and proteins and cell membranes from osmotic stress, and increases antioxidants for free radical reduction (Bacelar et al., 2009). Proline plays a key role in the plant defence system by acting as an osmoprotectant to regulate osmotic adjustment and buffering cellular redox potential under stress (Gupta et al., 2015; Karami et al., 2018). It involves in reconstruction of chlorophyll, activates the Krebs cycle and constitutes an energy source and also participates in repair processes (El-Khatib et al., 2020).

3.10. Superoxide dismutase activity

Superoxide Dismutase activity (Table 6) has shown significant difference among the ornamental plants, locations and in their interactions. Among the plants maximum value was obtained in *Cordyline terminalis* (2.94 O.D. min^{-1} g^{-1}) and in the locations highest superoxide dismutase activity was recorded at APMDC (2.14 O.D. min^{-1} g^{-1}), while the combination of *Cordyline terminalis* at APMDC showed best value (4.23 O.D. min^{-1} g^{-1}). Superoxide Dismutase (SOD) act as first line of defence against abiotic stress-accrued enhanced ROS and it catalyses the dismutation of O_2^- to H_2O_2 and O_2 (Karami et al., 2018). Superoxide

Table 6: Response of native ornamental plants (OP), locations (L) and their interaction (OP×L) to various pollutants in respect of biochemical traits

Orn. plants	Proline content (µmoles g^{-1})								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	1.411	6.281	3.918	2.289	3.312	3.437	3.912	3.683	3.53
OP_2	0.961	3.396	2.461	3.468	2.284	2.552	3.163	2.455	2.592
OP_3	2.971	9.198	6.124	7.268	4.663	7.149	5.862	7.996	6.404
OP_4	2.564	5.984	3.681	3.286	3.249	6.493	3.917	3.984	4.145
OP_5	1.182	7.742	4.681	2.981	2.463	5.817	4.218	1.529	3.827
OP_6	2.086	6.824	3.186	3.286	2.419	7.694	3.622	4.056	4.147
OP_7	1.875	3.195	4.245	2.714	2.816	5.185	2.284	2.119	3.054
OP_8	2.918	6.584	3.596	6.289	4.219	7.246	3.549	4.691	4.886
OP_9	1.432	5.129	2.991	4.499	2.376	3.891	3.028	1.983	3.166
OP_{10}	2.374	7.435	5.168	6.182	5.248	5.694	6.199	5.319	5.452
Mean	1.977	6.177	4.005	4.226	3.305	5.516	3.975	3.782	
CD (p<0.05)		L 0.034		OP 0.038		L×OP 0.108			

Table 6: Continue...

Orn. plants	Superoxide dismutase activity (O.D. min^{-1} g^{-1})								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	0.696	0.708	0.912	2.688	1.272	1.044	0.804	0.732	1.107
OP_2	1.269	0.576	0.84	1.164	1.176	2.04	0.66	1.38	1.138
OP_3	2.386	4.238	2.461	3.588	2.544	2.472	2.76	3.132	2.948
OP_4	2.256	2.112	2.052	1.812	2.184	2.388	3.42	2.04	2.283
OP_5	0.624	2.472	1.983	1.524	0.744	2.184	2.028	0.672	1.529
OP_6	2.052	2.736	0.66	1.296	1.56	0.828	1.164	1.86	1.519
OP_7	0.84	1.103	1.788	0.936	1.944	2.076	0.408	2.472	1.446
OP_8	1.794	3.688	2.256	3.173	2.292	1.967	1.644	3.555	2.546
OP_9	0.792	2.808	0.792	1.644	0.432	1.392	0.588	0.516	1.12
OP_{10}	0.66	0.972	0.828	1.956	1.5	1.896	1.188	1.74	1.342
Mean	1.337	2.141	1.457	1.978	1.565	1.829	1.466	1.81	
CD (p<0.05)		L 0.015		OP 0.017		L×OP 0.047			

dismutase activity was observed to higher at polluted sites which gives resistance to the plants.

3.11. Specific leaf weight

Among the studied plants at multiple locations specific leaf weight (Table 7) showed no significant difference. The specific leaf weight was highest in the control site while it reduced and similar in all the study locations. Pollutants majorly affect the growth and physiology of plants, at locations with higher pollutants photosynthate reserves in leaves are observed to be very poor due to reduced photosynthesis. As specific leaf weight (SLW) is the measure of dry matter accumulation leaf $area^{-1}$ this reduced photosynthates production leads to less dry matter accumulation in the plant leaves (Darrall, 1989).

3.12. Dust capturing capacity

Dust capturing capacity (Table 8) by ornamental plants at various polluted sites and their interactions showed significantly value, *Nyctanthus arbor-tristis* among the plants showed higher dust capturing capacity (0.21 mg cm^{-2}), among the study locations, APMDC registered higher dust capturing (0.15 mg cm^{-2}) and in the interactions, *Nyctanthus arbortristis* at APMDC attained highest dust capturing (0.31 mg cm^{-2}). Various factors like such as leaf shape and size, orientation, texture, presence or absence of hairs, length

Table 7: Response of native ornamental plants (OP), locations (L) and their interaction (OP×L) to various pollutants in respect of physiological traits

Orn. plants	Specific leaf weight (g cm^{-2})								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	0.005	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004
OP_2	0.003	0.002	0.003	0.003	0.002	0.002	0.002	0.003	0.002
OP_3	0.005	0.004	0.004	0.005	0.004	0.004	0.005	0.005	0.004
OP_4	0.007	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.006
OP_5	0.005	0.004	0.004	0.004	0.005	0.005	0.004	0.005	0.004
OP_6	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.004	0.003
OP_7	0.004	0.003	0.003	0.004	0.004	0.004	0.003	0.004	0.004
OP_8	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003
OP_9	0.019	0.017	0.018	0.018	0.018	0.018	0.018	0.019	0.018
OP_{10}	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.003	0.003
Mean	0.006	0.005	0.005	0.005	0.005	0.005	0.005	0.005	
CD (p<0.05)	L 0.00030		OP 0.00036			L×OP 0.003			

of petioles, presence of wax on leaf surface, canopy structure, weather conditions, direction and speed of wind and anthropogenic activities influence the dust capturing and its accumulation in different plant species. Plants with dense canopies, large horizontally arranges leaves with rough leaf surface and with numerous veins are identified as effective characteristics of plants for dust capturing (Prajapati and Tripathi, 2008; Sett, 2017).

3.13. Air pollution tolerance index

APTI (Table 8) varied significantly with the influence of plants, locations and combinations. *Cordyline terminalis* had highest APTI value (18.93) among plants, among the study locations, APMDC registered higher APTI value (14.63) and in the interactions *Cordyline terminalis*×APMDC reported highest value (21.86). Categorising plants to tolerant and sensitive group can be done using APTI values (Gupta et al., 2020). Plants with higher APTI value can be considered tolerant to air pollution and can be utilized to reduce pollution levels (Achakzai et al., 2017; Sharma et al., 2017; Pandey et al., 2015). The tolerant plants species can also support in pollution accumulation, with the expanding industrial and commercial areas, planting pollution tolerant

Table 8: Response of native ornamental plants (OP), locations (L) and their interaction (OP×L) to various pollutants in respect of dust capturing capacity and air pollution tolerance index (APTI) traits

Orn. plants	Dust capturing capacity (mg cm^{-2})								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	0.08	0.19	0.10	0.11	0.17	0.17	0.09	0.12	0.13
OP_2	0.09	0.12	0.11	0.12	0.11	0.19	0.10	0.13	0.12
OP_3	0.09	0.11	0.09	0.09	0.11	0.13	0.11	0.15	0.11
OP_4	0.08	0.13	0.13	0.10	0.12	0.12	0.10	0.13	0.11
OP_5	0.14	0.14	0.15	0.12	0.13	0.12	0.15	0.16	0.14
OP_6	0.10	0.15	0.12	0.13	0.12	0.13	0.12	0.14	0.13
OP_7	0.06	0.11	0.08	0.08	0.09	0.09	0.08	0.09	0.09
OP_8	0.16	0.31	0.17	0.20	0.21	0.22	0.18	0.19	0.21
OP_9	0.02	0.10	0.05	0.06	0.07	0.07	0.08	0.09	0.07
OP_{10}	0.07	0.12	0.09	0.11	0.11	0.11	0.11	0.11	0.11
Mean	0.09	0.15	0.11	0.11	0.12	0.14	0.11	0.13	
CD (p<0.05)		L 0.001		OP 0.001		L×OP 0.003			

Orn. plants	Air pollution tolerance index								
	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Mean
OP_1	13.87	17.54	15.39	14.60	18.27	17.23	16.64	18.30	16.48
OP_2	8.40	10.22	9.41	8.76	11.07	9.78	9.23	8.71	9.45
OP_3	14.94	21.86	17.55	19.61	20.06	20.35	19.09	17.95	18.93
OP_4	9.55	12.63	10.87	10.91	10.95	11.05	10.63	10.47	10.88
OP_5	8.73	11.96	10.50	11.75	12.18	10.35	11.17	11.42	11.01
OP_6	12.10	17.29	14.30	13.51	16.32	16.68	16.35	12.64	14.90
OP_7	8.85	11.22	10.98	10.15	9.78	10.24	10.41	10.47	10.26
OP_8	9.15	12.78	13.01	13.32	13.73	12.07	12.86	12.64	12.40
OP_9	12.34	14.23	13.54	15.33	13.00	14.47	11.91	14.23	13.63
OP_{10}	13.02	16.59	14.05	13.41	14.79	16.80	14.62	16.07	14.92
Mean	11.09	14.63	12.96	13.14	14.01	13.90	13.29	13.29	
CD (p<0.05)		L 0.096		OP 0.107		L×OP 0.304			

species to remediate contaminated areas is a long-term solution (Mok et al., 2013).

3.14. Anticipated performance index

Evaluation of plants based on API revealed (Table 9) that during post-monsoon season *Nyctanthus arbortristis* has been assessed as a very good performer with highest API grade of 5, followed by *Cordyline terminalis, Barleria cristata, Ixora coccinea* and *Sansevieria roxburghiana* were categorised into good performers with API grade of 4. *Tabernaemontana divaricata* with API grade 3 has been categorised to moderate performer and *Dracaena marginata* 'Coloroma' and *Chlorophytum comosum variegatum* were categorised to poor (API- 2) and very poor (API-1) respectively, while *Dracaena reflexa* and *Polyscias fruiticosa* has been categorised to not recommended with their API grade values of 0.

Anticipated Performance Index (API) is helpful in assessing the plant species for its capability in abatement of atmospheric pollutants and in green belt development (Mondal et al., 2011). API can be used as an indicator to evaluate plant species as it considers biological, biochemical, and socio-economic characteristics of plant species for identifying the most suitable plant species that can be suggested for green belt development in urban areas. The plants with API score of more than 50% can be strongly

Table 9: Gradation of plant species based on anticipated performance index (API)

Orn. plants	Post-monsoon API grading										
	APTI	Plant habit	Canopy structure	Type of plant	Leaf size	Leaf texture	Hardi-ness	Economic value	Total	% score	API grade	Assessment
OP_1	+++	+	+	+	+	+	+	++	11	68.75	4	Good
OP_2	+	-	-	+	+	-	-	++	5	31.25	1	Very poor
OP_3	++++	+	+	+	++	-	+	+	11	68.75	4	Good
OP_4	+	+	+	+	+	-	+	+	7	43.75	2	Poor
OP_5	+	-	-	+	+	-	+	-	4	25.00	0	Not recommended
OP_6	++	+	+	+	+	-	+	++	10	62.50	4	Good
OP_7	+	-	-	+	-	-	-	-	2	12.50	0	Not recommended
OP_8	++	++	++	+	+	+	+	++	12	75.00	5	Very Good
OP_9	++	+	+	+	++	-	+	++	10	62.50	4	Good
OP_{10}	++	+	+	+	+	-	+	++	9	56.25	3	Moderate

recommended for planting in urban areas, while plants with a score of less than 50% should be avoided for plantation (Patel et al., 2023). Plants with high API values are suited for green belts, while those with low API values indicate poor air quality (Sharma et al., 2020).

4. CONCLUSION

Native ornamental plants for their performance and ecofriendly way to mitigate the pollutants revealed that ornamental plants *viz.*, *Nyctanthus arbortristis, Cordyline terminalis, Barleria cristata, Ixora coccinea* and *Sansevieria roxburgiana* showed better performance with superior APTI and API grades and could be recommended for landscaping and in green belt development at highly polluted factory sites.

5. ACKNOWLEDGEMENT

The Authors extend sincere thanks to the Department of Floriculture and Landscaping, College of Horticulture, Anantharajupeta, Dr. YSR Horticultural University, A.P., India. for providing necessary facilities to fulfill the research work.

6. REFERENCES

Achakzai, K., Khalid, S., Adress, M., Bibi, A., Ali, S., Nawaz, R., Rizwan, M., 2017. Air pollution tolerance index of plants around brick kilns in Rawalpindi, Pakistan. Journal of Environmental Management 190, 252–258.

Ahmad, I., Abdullah, B., Dole, J.M., Shahid, M., Ziaf, K., 2019. Evaluation of the air pollution tolerance index of ornamentals growing in an industrial area compared to a less polluted area. Horticulture Environment and Biotechnology 60, 595–601.

Azzazy, M.F., 2020. Plant bioindicators of pollution in Sadat City, Western Nile Delta, Egypt. PLoS ONE 15(3), e0226315. https://doi.org/ 10.1371/journal.pone.0226315.

Bacelar, E.A., Moutinho-Pereira, J.M., Gonçalves, B.C., Lopes, J.I., Correia, C.M., 2009. Physiological responses of different Olive genotypes to drought conditions. Acta Physiologiae Plantarum 31, 611–621.

Banerjee, T., Singh, S.B., Srivastava, R.K., 2011. Development and performance evaluation of statistical models correlating air pollutants and meteorological variables at Pantnagar, India. Atmospheric Research 99(3–4), 505–517.

Bang, Q.H., 2012. Urban air pollution, air pollution - monitoring, modelling and health. In: Khare, M (Ed.), InTech: http://www.intechopen.com/books/air-pollutionmonitoring modelling-and-health/urban-air-pollution.

Barnes, J.D., Balaguer, L., Manrique, E., Elvira, S., Davison, A.W., 1992. A reappraisal of the use of DMSO for the extraction and determination of chlorophyll a and b in lichens and higher plants. Environmental and Experimental Botany 32, 85–100.

Bates, I.S., Waldren, R.P., Tarc, I.D., 1973. Rapid determination of free proline for water stress studies. Plant and Soil 39, 205–207.

Bharadwaj, A., Aggarwal, R.K., Bharadwaj, S.K., 2021. Study on spatial and seasonal variation in APTI of tree species along roads of Shivalik foothills in Himachal Pradesh. International Journal of Bio-resource and Stress Management 12(3), 247–254.

Darrall, N.M., 1989. The effect of air pollutants on physiological processes in plants. Plant Cell and Environment 12(1), 1–30.

El-Khatib, A.A., Youssef, N.A., Barakat, N.A., Samir, N.A., 2020. Responses of *Eucalyptus globulus* and *Ficus nitida* to different potential of heavy metal air pollution. International Journal of Phytoremediation 22(10), 986–999.

Escobedo, F.J., Wagner, J.E., Nowak, D.J., De la Maza, C.L., Rodriguez, M., Crane, D.E., 2008. Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. Journal of Environmental Management 86(1), 148–157.

Govindaraju, M., Kumar, G.R.S., Muthukumaran, V.R., Visvanathan, P., 2012. Identification and evaluation of air-pollution-tolerant plants around lignite-based thermal power station for greenbelt development. Environmental Science and Pollution Research 19, 1210–1223.

Gupta, G.P., Singh, S., Kumar, B., Kulshrestha, U.C., 2015. Industrial dust sulphate and its effects on biochemical and morphological characteristics of Morus (*Morus alba*) plant in NCR Delhi. Environmental Monitoring and Assessment 187(3), 1–13.

Gupta, A., Kumar, M., Chauhan, A., Kumar, A., Tripathi, A., 2020. Assessment of air pollution tolerance index and evaluation of air pollution anticipated performance index of various plants and their application in planning of Moradabad city, India. Pollution Research 39(4), 1273–1283.

Hassanen, R.A., Morsy, A.A., Saleh, H.A., 2016. Leaf dust accumulation and air pollution tolerance indices of three plant species exposed to urban particulate matter pollution from a fertilizer factory. Vegetos 29, 3.

Hazarika, M., Borah, G., Singha, W.J., Deka, H., 2023. Metals stress on soil enzyme activities and herbs defense in the vicinity of high traffic roadways. Environmental Monitoring and Assessment 195, 1546.

Kapoor, M., 2017. Managing ambient air quality using ornamental plants-an alternative approach. Universal Journal of Plant Science 5(1), 1–9.

Karami, H., Rezaei, M., Sarkhosh, A., Rahemi, M., Jafari, M.J.G.P., 2018. Cold hardiness assessment in seven commercial fig cultivars (*Ficus carica* L.). Gesunde Pflanzen 70(4), 195–203.

Keller, T., Schwager, H., 1977. Air pollution and ascorbic acid. European Journal for Plant Pathology 7, 338–350.

Kovácik, J., Backor, M., 2007. Changes of phenolic metabolism and oxidative status in nitrogen-deficient *Matricaria chamomilla* plants. Plant and Soil 297, 255–265.

Kuo, C.G., Hsu, F.H., Tsay, J.S., Park, H.G., 1980. Variation in specific leaf weight and RuDPCase activity in Mungbean. Canadian Journal of Plant Science 60(3), 1059–1062.

Kuddus, M., Kumari, R., Ramteke, P.W., 2011. Studies on air pollution tolerance of selected plants in Allahabad City, India. Journal of Environment Research and Management 2, 42–46. https://www.semanticscholar.org/paper/Studies-on-air-pollution-tolerance-of-selected-in-Kuddus-Kumari/55c2d364135f148f0c6442500f888c9e7540c1e5.

Lima, J.S., Fernandes, E., Fawcett, W., 2000. *Mangifera indica* and *Phaseolus vulgaris* in the bioindication of air pollution in Bahia, Brazil. Ecotoxicology and Environment Safety 46, 275–278.

Manisha, S.P.E., Pal, A.K., 2014. Dust arresting capacity and its impact on physiological parameter of the plants. Strategic Technologies of Complex Environmental Issues-A Sustainable Approach, 111–115.

Mohan, M.M., Lakshmi, N.S., Ibrahim, S.M., 2000. Chlorophyll stability index (CSI): Its impact on salt tolerance in rice. International Rice Research Notes 25, 38–39.

Mok, H.F., Majumder, R., Laidlaw, W.S., Gregory, D., Baker, A.J., Arndt, S.K., 2013. Native Australian species are effective in extracting multiple heavy metals from biosolids. International Journal of Phytoremediation 15(7), 615–632.

Murthy, K.S., Majumdar, S.K., 1962. Modifications of the technique for determination of chlorophyll stability index in relation to studies of drought resistance in rice. Current Science 31, 470–471.

Mukherjee, S., Chakraborty, A., Mondal, S., Saha, S., Haque, A., Paul, S., 2019. Assessment of common plant parameters as biomarkers of air pollution. Environmental Monitoring and Assessment 191, 400.

Nugrahani, P., Prasetyawati, E.T., Sugijanto, O., Pumobasuki, H., 2012. Managing ambient air quality using ornamental plants-an alternative approach. Asian Journal of Biological Sciences 3(2), 298–302.

Ogunkunle, C.O., Suleiman, L.B., Oyedeji, S., Awotoye, O.O., Fatoba, P.O., 2015. Assessing the air pollution tolerance index and anticipated performance index of some tree species for biomonitoring environmental health. Agroforestry Systems 89, 447–454.

Olumi, H., Rezanejad, F., Keramat, B., 2016. Comparative study of biochemical parameters of P. *inusnigra* and P. *elderica* cultivated in the area around sarcheshmeh copper complex and kantuyeh. Environmental Plant Physiology Journal 10(40), 1–12.

Pandey, A.K., Pandey, M., Tripathi, B.D., 2015. Air pollution tolerance index of climber plant species to develop vertical greenery systems in a polluted tropical city. Landscape and Urban Planning 144, 119–127.

Patel, K., Chaurasia, M., Rao, K.S., 2023. Urban dust pollution tolerance indices of selected plant species for development of urban greenery in Delhi. Environmental Monitoring and Assessment 195, 16.

Pravin, U.S., Madhumita, S.T., 2013. Physiological responses of some plant species as a bio-indicator of roadside automobile pollution stress using the air pollution tolerance index approach. International Journal of Plant Research 3, 9–16.

Prajapati, S.K., Tripathi, B.D., 2008. Seasonal variation of leaf dust accumulation and pigment content in plant species exposed to urban particulates pollution. Journal of Environmental Quality 37(3), 865–870.

Prasad, B.J., Rao, D.N., 1982. Relative sensitivity of a leguminous and a cereal crop to sulphur dioxide pollution. Environmental Pollution 29, 57–70.

Rai, P.K., Panda, L.L.S., Chutia, B.M., Singh, M.M., 2013. Comparative assessment of air pollution tolerance index (APTI) in the industrial (Rourkela) and non-industrial area (Aizawl) of India. An Ecomanagement Approach 7(10), 944–948. DOI: 10.5897/AJEST2013.1532.

Rai, P.K., 2016. Biodiversity of roadside plants and their response to air pollution in an Indo-Burma hotspot region: implications for urban ecosystem restoration. Journal of Asia-Pacific Biodiversity 9, 47–55.

Ranganna, S., 1977. Hand book of analysis and quality control for fruit and vegetable products. Tata Mc. Graw Hill publishing Co. Ltd. New Delhi, 29–31.

Rocha, C.M., Rocha, D.C., Kochi, L.Y., Carneiro, D.N.M., Dos Reis, M.V., Gomes, M.P., 2022. Phytoremediation by ornamental plants: a beautiful and ecological alternative. Environmental Science and Pollution Research 29, 3336–3354.

Roy, A., Bhattacharya, T., Kumari, M., 2020. Air pollution tolerance, metal accumulation and dust capturing capacity of common tropical trees in commercial and industrial sites. Science of the Total Environment 722, 137622.

Sadasivam, S., Manickam, A., 1996. Biochemical methods. New age international (P) Limited, Publishers, II New Delhi, 152–160.

Salisbury, E.J., 1927. On the causes and ecological significance of stomatal frequency with special reference to the wood land flora. Philosophical Transactions of the Royal Society of London 216, 1–65.

Sett, R., 2017. Responses in plants exposed to dust pollution. Horticulture International Journal 1(2), 53–56. DOI: 10.15406/hij.2017.01.00010.

Setala, H., Viippola, V., Rantalainen, A., Pennanen, A., Yli-Pelkonen, V., 2013. Does urban vegetation mitigate air pollution in northern conditions. Environmental Pollution 183, 104–112.

Sharma, B., Sharma, S., Bhardwaj, S.K., Kaur, L., Sharma, A., 2017. Evaluation of air pollution tolerance index (APTI) as a tool to monitor pollution and green belt development: A review. Journal of Applied and Natural Science 9, 1637–1643.

Sharma, A., Bhardwaj, S.K., Panda, L.R.L., Sharma, A., 2020. Evaluation of anticipated performance index of plant species for green belt development to mitigate air pollution. International Journal of Bio-resource and Stress Management 11(6), 536–541.

Singh, A., 1977. Practical plant physiology. Kalyani Publishers. New Delhi.

Singh, I.P., Pal, A., 2017. Response of dust accumulation on roadside plant species due to open cast mining at Jhansi-Allahabad NH-76, Uttar Pradesh. Tropical Plant Research 4(3), 461–467.

Singleton, V.I., Joseph, A., Rossi, 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. American Journal of Enology and Viticulture 16, 144–158.

Suganthi, P., Ganeshkumar, R.S., Govindaraju, M., Selvaraj, M., Kumar, P., 2013. Estimation of biochemical characters of plants in response to vechicular air pollution stress in Tiruchirappalli city corporation, Tamil Nadu. India. Journal of Experimental Biology 203(8), 3425–3434.

Uka, U.N., Hogar, J., Belford, E.J.D., 2017. Morpho-anatomical and biochemical responses of plants to air pollution. International Journal of Modern Botany 7(1), 1–11.

Verma, S., Dubey, R., 2003. Lead toxicity induces lipid peroxidation and alters the activities of antioxidant enzymes in growing rice plants. Plant Science 164, 645–655.